



A quality management review of Scotland's sectoral marine plan for tidal energy

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ABSTRACT

As coastal communities continue to increase in size and population, associated marine economies will have to expand in unison. This relationship gives rise to an increase in user – user and user – environment conflicts. Such conflicts demand the implementation of marine spatial planning (MSP) in order to effectively manage users and uses within the marine environment. Furthermore, climate change increasingly threatens the integrity of marine ecosystems, thereby affecting the economies of coastal communities. Political support for the adoption of off-shore renewable energy has increased in order to assist a transition away from carbon-based economies. These drivers have triggered Scotland to construct and implement the world's first sectoral marine plan for tidal energy (SMPTE). As this SMPTE is the first of its kind, it is important to include a quality assurance element in the plan framework. The authors have undertaken a quality management review of Scotland's SMPTE against guidelines set out in the International Council for Exploration of the Sea's *Marine Spatial Planning Quality Management System* (ICES MSP QMS). Conformity of the SMPTE to criteria set out in the ICES MSP QMS are ranked, gaps in quality management are analyzed, and recommendations are made for further improvement.

1. Introduction

Historically, the seas adjoining coastal nations have acted as a resource conduit to assist in the proliferation of the development and expansion of city states and nations. The value of the seas remains a theme in modern societies, with 44% of the global population living within 150 km of the coast (UN Atlas of the Oceans, 2010). Increasing emphasis on sustainable development of the sea reflects the potential of the seas to accommodate new activities (European Union, 2012) and the need to create compatible relations between new and established uses of the sea. Traditional coastal activities such as fishing, shipping, dredging, mineral extraction, and tourism have proved to be an economic stronghold for coastal communities (Douve and Ehler, 2009). The growth of coastal populations, in conjunction with the estimated 382 existing and emerging uses of the marine environment (Lester et al., 2013), can act to compromise the ecosystem integrity of marine environments at a pace greater than any other in human history (World Resources Institute, 2005). This dilemma is further exacerbated by the rapid warming of the Earth's climate due to the excessive combustion of fossil fuels. The combination of such regional user conflicts and global ecosystem stressors have led to scientific analysis suggesting that no portion of the Earth's oceans have escaped the influence of anthropogenic activities (Halpern et al., 2008).

User – user conflicts (interactions amongst various users of the marine environment) and user – environment conflicts (interactions of various users of the marine environment with natural ecosystem properties) (Douve, 2008) arising from the proliferation of marine activities in size, number, and intensity demand the application of marine spatial planning (MSP) as a means to effectively manage the environmental, economic, and social implications associated with their usage across time and space (Foley et al., 2010). The negative implications of global climate change have prompted a shift in all levels of government policy and legislation towards the reduction of greenhouse gases (GHG) and implementation of renewable energy sources. These two prerogatives become ever the more intertwined when examining the notion of tidal current energy development and implementation, as such renewable energy technology essentially becomes another player in the usage of finite and already stressed marine space.

Anticipating such conflicts in marine spatial usage, Scotland has become the first and only nation to draft a sectoral marine plan for tidal energy (SMPTE) with the intent of promoting the sustainable deployment of tidal current turbines (TCTs). The SMPTE takes into consideration areas characterized by strong tidal energy resources and the potential environmental, economic, and social constraints associated with developing such areas, ultimately resulting in the identification of ten potential commercial-scale tidal energy sites. However, TCT

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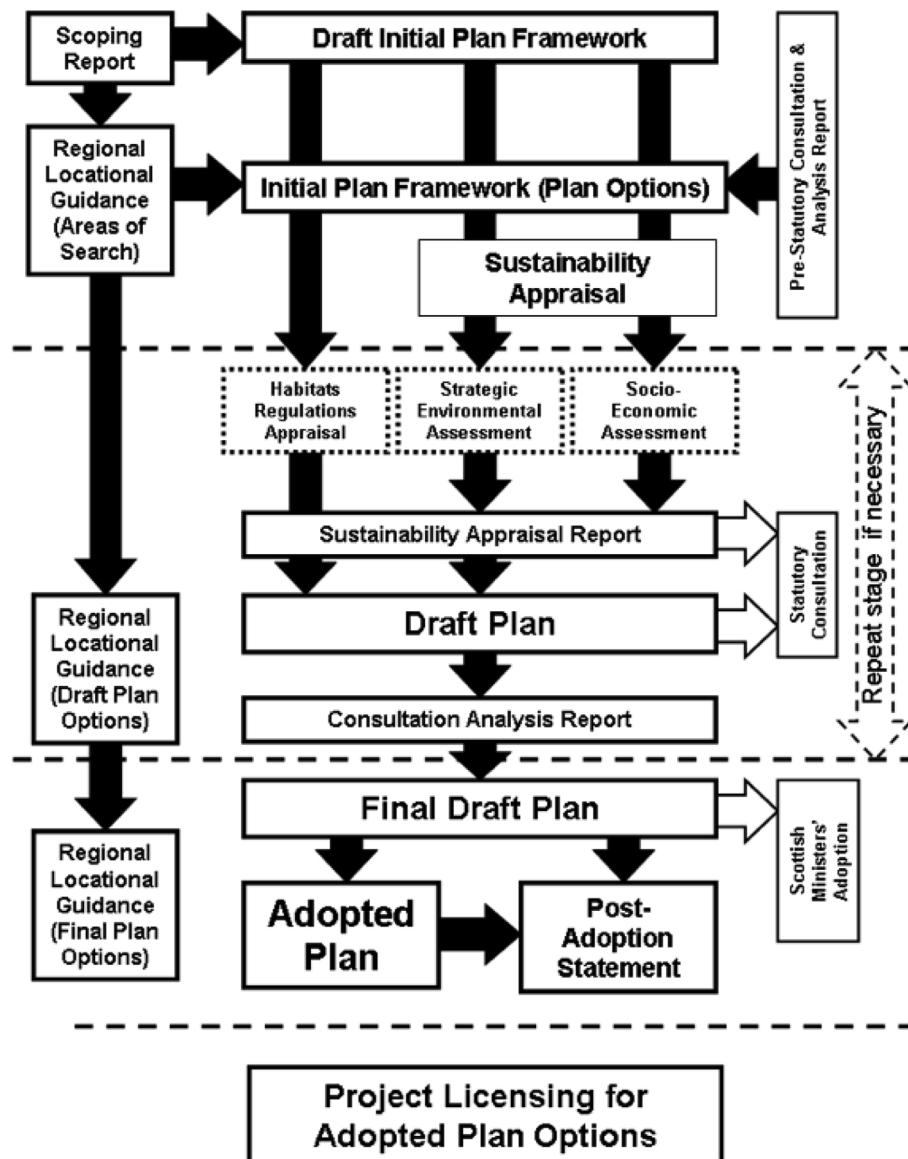


Fig. 1. Scotland's SMPTE process (Davies and Pratt, 2014).

deployment continues to develop into a mature commercial proposition (Myers et al., 2011), and, therefore, while many scholars have advocated the deployment of TCTs based on their suggested environmentally benign operational nature (Pelc and Fujita, 2002), favorable long term economics (Fraenkel, 2006), and ideal location of implementation on the seabed reducing public resistance generated from visual and/or audio pollution (Fraenkel, 2002), such effects cannot yet be confirmed. In order to address this issue, it is suggested within the SMPTE that a sectoral plans review group be established in order to oversee the implementation of the SMPTE and stimulate strategic monitoring and research to fill information gaps identified in the sustainability appraisal report. In partial response to the above, Marine Scotland Science undertook a review of quality management protocols of the SMPTE.

The International Council for Exploration of the Sea's (ICES) *Marine Spatial Planning Quality Management System* (MSP QMS) (Cormier et al., 2015) is the most recently published MSP quality assurance scheme. The ICES MSP QMS was preceded by UNESCO's *Marine spatial planning: a step-by-step approach toward ecosystem-based-management* (Ehler and Douvère, 2009) and the European Commission's *Establishing a Framework for Maritime Spatial Planning and Integrated Coastal Management*

(EC, 2013). All three documents propose a similar framework to structure the development of a MSP, loosely beginning with the establishment of a governance structure under existing legislation through to the review and monitoring of an implemented plan. The UNESCO document places some emphasis on development outcomes stimulated by the plan, and the European Commission document also emphasizes organizational and jurisdictional aspects. As the Scottish SMPTE is a relatively new document, there has been little time for its conclusions to work through into project development. The ICES document was therefore selected as the basis for the current review due to the process-oriented emphasis of the guideline, its more comprehensive granulated structure, and the fact that it provides a quality management checklist (QMC) of questions specifically developed to review the inputs, processes, and outputs of a MSP in relation to legal, political, technological, environmental, ecological, social, cultural, financial, and economic contexts (Cormier et al., 2015).

This paper presents a quality management review (QMR) of Scotland's SMPTE against criteria set out in the ICES MSP QMS. Consistencies between the SMPTE and the ICES criteria are identified and gaps in quality management are analyzed in order to provide recommendations for further improvement.

2. Materials and methods

2.1. Scotland's SMPTE

Scotland's SMPTE was first drafted in July 2013 based upon an earlier plan for the Saltire Prize (Marine Scotland, 2014). Powers to plan for the UK's exclusive economic zone (EEZ) between 12 and 200 nm out from Scotland's coasts were devolved from the UK Government to the Scottish Government (SG) in 2010, thereby empowering Scottish Parliament with planning authority over both their territorial zone (TZ, 0–12 nm) and EEZ. However, while marine plans for both the TZ and EEZ are uniform and published under Scotland's national marine plan (NMP), the authority to plan and manage development within the TZ and EEZ is derived from different legislation, with the TZ legislated by the Marine Scotland Act 2010 (The Scottish Government, 2010) and the EEZ legislated by the Marine and Coastal Access Act 2009 (The UK Government, 2009).

The SMPTE was constructed with the strategic aims of identifying preferred development areas for tidal energy implementation in Scotland, facilitating enhanced economic development, investment, and employment, and minimizing adverse interactions with people, other sectors, and the environment (Marine Scotland, 2013). The four key drivers that prompted the development of the SMPTE include:

- Climate change and energy: to assist the SG in achieving GHG emissions reduction targets of 42% below 1990 levels by 2020 and 80% below 1990 levels by 2050, as stated in the Climate Change (Scotland) Act 2010 (The Scottish Government, 2009). Furthermore, to assist the SG in achieving its commitment of providing 30% of Scotland's energy demand from renewables by 2020, with an interim embedded target of 100% renewably generated electricity.
- Marine planning: to inform the national and future regional marine plans with regards to the strategic siting of TCTs.
- Marine licensing: to streamline the licensing and consenting process of TCT testing and development.
- Transition to a low carbon economy: to exploit Scotland's tidal current resource in a sustainable manner in order to position Scotland as a world leader in the low carbon economy transition in the resulting four decades.

Scotland's SMPTE utilized the sectoral marine planning process illustrated in Fig. 1 to designate the 10 plan option areas (POAs) presented in Fig. 2 with the capacity to accommodate projects of 30 MW or greater in areas where social, environmental, economic, and industry factors demonstrated the least levels of constraint on development (Davies and Pratt, 2014).

2.2. ICES MSP quality management system (QMS)

2.2.1. Quality management system (QMS)

In February 2010, ICES (ICES, 2012) held a Workshop on Quality Management of MSP Processes. Key findings of the workshop revealed that the overwhelming majority of QMSs linked to MSPs were implemented on an *ad hoc* basis throughout the entire planning process, including data collection and dissemination, policy advisory, stakeholder consultation, conformity auditing, and policy development and implementation. This in turn led to the development of MSP processes that lacked a solid QMS that could ensure confidence and buy-in from relevant sectoral and community stakeholders. The aim of the ICES's document is to put forward a uniform MSP QMS structure to enable the standardization of best practices in MSP processes (Cormier et al., 2015), thereby providing confidence to internal and external stakeholders that the output of the plan fulfills the objectives established at the onset of the MSP process (Hoyle, 2011). Best practices require that MSP and QMS frameworks draw upon four key elements:

- a) Defining stressors and identifying appropriate management measures of such stressors.
- b) Constructing risk assessment and risk management measures.
- c) Defining stakeholders, identifying stakeholder interactions, and ascertaining the vertical stratification of multilateral government institutions.
- d) Identifying ecosystem services, the societal benefits of such services, and adopting an ecosystem approach to management.

In order to apply these four elements to the construction of a QMS framework, the ICES document draws upon key concepts within the MSP field to integrate themes of MSP processes (Ehler and Douvère, 2009), (Schultz-Zehden et al., 2008), ecosystem management systems (Sardà et al., 2010), (Sardà et al., 2014), ecosystem approaches to management (Rice et al., 2005), and ecosystem risk management (Cormier et al., 2013). While all of the elements and themes listed above can inform the development of a MSP QMS, none of these documents were written from a quality management perspective. Therefore, ICES sought to fill the void through the creation of their MSP QMS best practice document (Cormier et al., 2015). In addition to the guiding elements, themes, and documents listed above, the ICES document draws upon ISO (2005) 9000 quality systems suite of standards (ISO, 2005) in order to construct its QMS and the ISO (2009) 31000 risk management standards (ISO, 2009) in order to manage interrelated processes within the overall MSP framework.

In order to properly implement an effective, transparent QMS for MSP, a quality management programme (QMP) with an itinerary that specifies required inputs and targeted outputs, quality objectives of the plan (QOP) that document the desired outcome of the end product, and quality management objectives (QMO) that deal with interrelated processes are all essential components (Cormier et al., 2015).

2.2.1.1. Quality management programme (QMP). A QMP structures the sequence of activities in order to determine how the MSP will establish its “scope and objectives, identify issues or conflicts, evaluate management options, develop and implement the plan, monitor and review the plan, in addition to establishing who is part of the governance structure, who makes decisions, who will be consulted and provide advice, and how information is managed” (Cormier et al., 2015). A QMP must include four compulsory elements in order to achieve its purpose, notably:

- Mandate and commitment: by a government institution headed by a Competent Authority (CA) in order to maintain political, sectoral, and community engagement throughout the MSP process.
- Communication and consultation: from both statutory and non-statutory actors in order to develop a knowledge base of potential risks and search for methods to manage, and if necessary, mitigate such risks.
- Information and record management requirements: in order to demonstrate the methodology behind management decisions within the MSP process and prove conformity with criteria set out in the QMS.
- Evaluations and performance assessments: in order to assess the performance of the MSP and the conformity of objectives with overarching policy goals within the MSP as determined by the applicable political framework.

2.2.1.2. Quality management objectives (QMO). QMOs are “principles upon which the conduct of governance, consultation, advisory, and decision-making will ensure that the process remains within the scope, objectives, and outcomes established at the onset of the planning initiative, that the steps and outputs of the planning process are relevant to achieving the plan, and that the plan addresses the quality assurance elements outlined by the QOPs”. QMOs are essentially the quality objectives for the MSP as a process in and of itself. The ICES

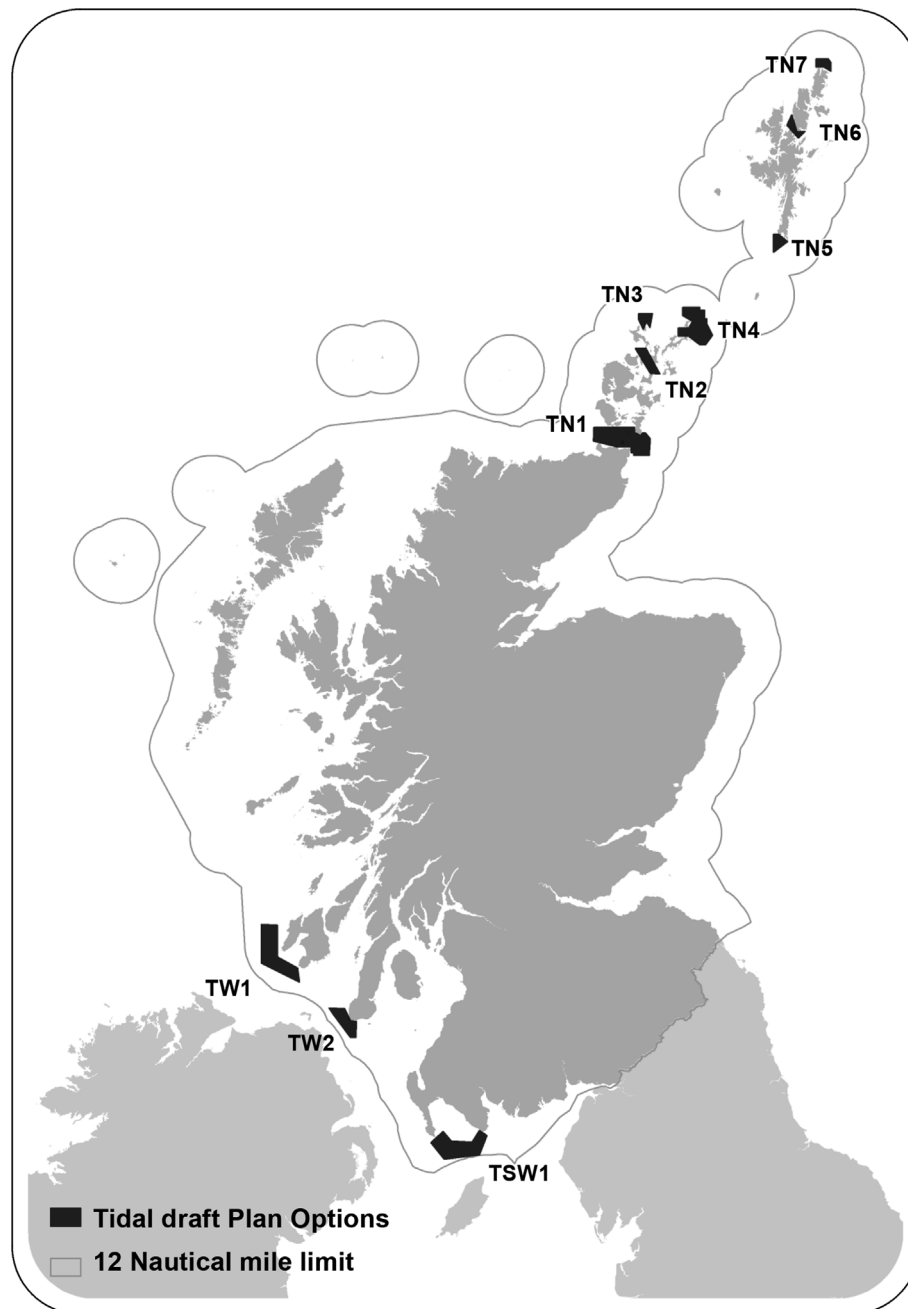


Fig. 2. SMPTE plan option areas (Marine Scotland, 2013).

MSP QMS document draws from Hoyle's (Hoyle, 2011) seven process principles to establish the QMO framework, consisting of:

- P1 – Consistency of purpose: between the purpose of the MSPs outputs and QMOs in order to allow for outputs to be informed by CAs and sectoral and community stakeholders.
- P2 – Clarity of purpose: quantifiable objectives with defined outputs throughout each step of the MSP process, thereby allowing those involved in the process to understand their roles, the MSPs purpose, and how performance will be measured.
- P3 – Connectivity with objectives: activities undertaken in the MSP process justify the ability of the MSP to achieve its QMOs, and subsequently ensure that those involved in the MSP are working towards achieving the QMOs
- P4 – Competence and capability: of those involved in the MSP process to ensure that roles are properly assigned and individual

inputs hold weight.

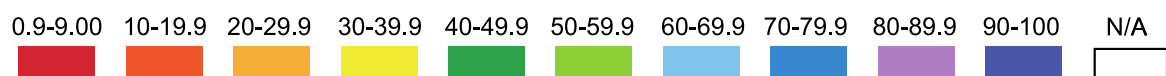
- P5 – Certainty of results: are enhanced if performance indicators and stipulated periodic reporting are a part of the MSP process, thereby allowing those involved in the MSP process, both internally and externally, to comprehend the performance and progress of the MSP process.
- P6 – Conformity to best practices: to ensure that the MSP process is structured off of past success, thereby providing confidence in its effectiveness and efficiency.
- P7 – Clear line of sight: undertaking periodic reporting to ensure CAs and sectoral and community stakeholders can identify the connectivity between their expectations and the QOPs, thereby providing a better understanding of the MSP process and facilitating the continual improvement of the MSP process over time.

2.2.1.3. *Quality objectives of the plan (QOP)*. QOPs are a

Table 1
SMPTE QMR conformity scores and rankings.

ICES MSP QMS Components	Score	Conformity %
Establishing the external context	3/6	50
Public policy governance	N/A	N/A
Marine development policy agenda	2/3	66.7
Ecosystem protection public policy agenda	1/3	33.3
Establishing the internal context	60/71	84.5
Marine planning legislation, policies, and authorities	5/5	100
Ecosystem legislation, policies, and authorities	5/5	100
Competent authorities	2/2	100
Industry stakeholders	3/3	100
Communities of interest	3/3	100
Consultation and feedback process	0/4	0
Public	1/1	100
Public communication procedures	3/4	75
Scientific and technical advisory bodies	2/3	66.7
Scientific and technical advisory process	4/4	100
Governance body	2/2	100
Governance terms of reference	2/6	33.3
Governance business rules	5/5	100
MSP risk criteria	4/4	100
Ecosystem management outcomes	3/4	75
MSP management outcomes	5/5	100
MSP secretariat	10/11	90.9
Risk identification	16/23	69.6
Significant ecosystem components	4/7	57.1
Significant ecosystem services	3/5	60
Significant driver activities and pressures	3/4	75
Management area regulatory requirements	3/4	75
Risk profile	3/3	100
Risk analysis	11/15	73.3
Cause and effect analysis	1/5	20
Impacts, consequences, and repercussions	7/7	100
Risk matrix	3/3	100
Risk evaluation	14/15	93.3
Management measures evaluations	4/4	100
Existing management measures acceptable for the marine spatial plan	3/3	100
New or enhance management measures needed for the marine spatial plan	5/5	100
Marine spatial risk register	2/3	66.7
Risk treatment	10/16	62.5
Spatial and temporal management options	1/3	33.3
Management options costs, benefit, and feasibility	3/7	42.9
Marine spatial plan	6/6	100
Monitoring and review	26/30	86.7
MSP implementation	2/2	100
Compliance verification and auditing	9/9	100
Ecosystem status and trends monitoring	6/8	75
Cultural and socio-economic monitoring	3/5	60
Marine spatial plan periodic review	6/6	100
Total	140/176	79.5

Conformity with ICES MSP QMS (%)



“comprehensive list of the quality assurance elements that should be addressed by the plan in terms of legislation, policies, governance, cultural, social, economic, and technological considerations in its management strategies” (Cormier et al., 2015). QOPs provide a framework for what the MSP process should achieve. The ICES MSP QMS document draws from Elliot's (Elliot, 2013) ten tenets to establish the QOP framework, consisting of

- T1 – Environmentally/ecologically sustainable: enacting measures to ensure that ecosystem services are sustained.
- T2 – Technologically feasible: tools required to sustain ecosystem services are readily available.
- T3 – Economically viable: cost-benefit analysis of sustaining ecosystem services demonstrates viability.
- T4 – Socially desirable/tolerable: management processes are understood and tolerated by society and result in societal benefit.
- T5 – Legally permissible: policy and legislation are in place to enact and/or enforce management measures.
- T6 – Administratively achievable: statutory bodies are in place to ensure sustainable management.
- T7 – Politically exponent: management measures are in conformance with prevailing policy and obtain support from political leaders.
- T8 – Ethically defensible: ensuring that management measures that allow for some degree of environmental deterioration can be justified.
- T9 – Culturally inclusive: cultural ecosystem values are incorporated into management measures.
- T10 – Effectively communicable: management measures are understood by all stakeholders in relation to the nine other tenets.

2.3. QMS components

Elements of the QMP, QMO, and QOP contained within the ICES MSP QMS are all intrinsically linked to one another in accordance with ISO 3100 risk management standards in order to support the goals and objectives set out at the beginning of the MSP process (Cormier et al., 2015). Various elements of these broader envelopes are partitioned into seven components which chronologically categorizes the MSP construction process. These components are:

- Establishing the external context
- Establishing the internal context
- Risk identification
- Risk analysis
- Risk evaluation
- Risk treatment
- Monitoring and review

2.4. QMC assessment methodology

In order to determine the effectiveness of the SMPTE in conformity to the criteria set out in the ICES MSP QMS, various elements, functions, and processes of the plan were assessed against the 178 questions provided in the ICES QMC (Cormier et al., 2015). The QMC provides for questions under interrelated subtopics, themes, and associated principles and tenets which are to be applied to the MSP construction process. Answers drawn from the SMPTE pertaining to questions emanating from the QMC were considered to be in conformity if the SMPTE could demonstrate that the appropriate internal and/or external organizations could be aligned to stated roles within the SMPTE process, and if inputs and outputs and/or functions of the SMPTE process took into consideration the criteria put forth in the ICES document. Given that the SMPTE must be in conformity with the objectives and policies set out in the NMP (Marine Scotland, 2014), the NMP was referred to for questions emanating from the QMC which dealt with matters which

underpin the SMPTEs construction, implementation, and management within the larger context of the Scottish marine environment and public policy agenda. Answers received one full score if the SMPTE demonstrated complete conformity to the question, no score if all criteria within a given question were not addressed, and a neutral score if the question was deemed irrelevant to the sectoral context, whereby the overall weighting is adjusted accordingly. Each question received an equal weighting and are represented in this paper under the seven QMS components detailed in section 2.3. The assessment process was informed by the SMPTE, and Scotland's NMP, the detailed supporting documents published to inform the construction, consultation and adoption processes for the SMPTE and NMP, supplemented where necessary with interviews with SG officials.

3. Results

The QMR of Scotland's SMPTE against the ICES MSP QMS demonstrates a 79.5% conformity with best practice standards set out in the ICES document, scoring 140/176, with two neutral scores. The following subsections present the ranking percentage breakdown for each section and subsection of the ICES QMC (see Table 1).

3.1. Establishing the external context

In order to devise a successful MSP process, the external context consisting of cultural, social, political, legal, regulatory, financial, technological, economic, and environmental factors that may influence the ability of the MSP to achieve its objectives must be taken into consideration (Cormier et al., 2015). The SMPTE demonstrated a 50% conformance ranking in relation to the ICES QMC specific to establishing the external context, scoring 3/6, plus one neutral score. This is the lowest conformity ranking amongst all seven sections of the ICES QMC.

3.2. Establishing the MSP internal context

In order to devise a successful MSP process, the internal context consisting of governance, organizational structure, roles and accountabilities, and human and financial resources, that may influence the ability of the MSP to achieve its objectives must be taken into consideration (Cormier et al., 2015). The ICES MSP QMS seeks terms of references, business rules, communication and consultation procedures, auditing framework, and scientific and technical advisory protocols. The SMPTE demonstrated an 84.5% conformance ranking in relation to the ICES QMC specific to establishing the internal context, scoring 60/71 plus one neutral score. This represents the third highest conformity ranking amongst all seven sections of the ICES QMC.

3.3. Risk identification

Drawing upon the ISO 31000 risk management standard, risk identification is defined as the process of finding, recognizing and describing risks, including all possible sources, events, causes, and consequences of risk both within and outside the management area in which operational and environmental events resulting from the activities of drivers have the potential to produce ecological, cultural, social, economic, and legal repercussions (Cormier et al., 2015). In the context of a MSP QMS, risk identification produces a risk profile which informs the construction of a risk assessment that will estimate the probability and impact of each risk identified. Therefore, it is essential that the risk identification process is scoped appropriately as any risk excluded from the risk identification, and subsequently the risk profile, will not be taken into consideration for the remainder of the MSP process. The SMPTE demonstrated a 69.6% conformance ranking in relation to the ICES QMC specific to risk identification, scoring 16/23. This represents the third lowest conformity ranking amongst all seven sections of the

ICES QMC.

3.4. Risk analysis

Risk analysis is defined as the process of comprehending and determining the probability and impact of risks both within and outside the management area in which operational and environmental events resulting from the activities of drivers have the potential to produce ecological, cultural, social, economic, and legal repercussions (Cormier et al., 2015). Informed by the risk profile generated from the risk identification process, the contents of the risk analysis will feed into the risk evaluation process which will establish the severity of the risks to inform risk treatment procedures. The SMPTE demonstrated a 73.3% conformance ranking in relation to the ICES QMC specific to risk analysis, scoring 11/15. This represents the middle range conformity ranking amongst all seven sections of the ICES QMC.

3.5. Risk evaluation

Drawing upon the ISO 31000 risk management standard, risk evaluation is defined as the process of comparing the output of the risk analysis with risk criteria in order to discern whether risks are acceptable and/or tolerable by all stakeholders engaged within the planning process (Cormier et al., 2015). Outputs of the risk evaluation process inform the management and/or mitigation measures formulated during the risk treatment process. The SMPTE demonstrated a 93.3% conformance ranking in relation to the ICES QMC specific to risk evaluation, scoring 14/15. This represents the highest conformity ranking amongst all seven sections of the ICES QMC.

3.6. Risk treatment

Risk treatment is defined as the process of either modifying risk through avoidance, eliminating risk sources, or reducing risk through prevention or mitigation of consequences (Cormier et al., 2015). Drawing upon management options identified in risk evaluation and documented in the risk register, risk treatment devises spatial and temporal management measures that take into consideration the costs, benefits, and feasibility of implementing the MSP as its output. The SMPTE demonstrated a 62.5% conformance ranking in relation to the ICES QMC specific to risk treatment, scoring 10/16. This represents the second lowest conformity ranking amongst all seven sections of the ICES QMC.

3.7. Monitoring and review

Drawing upon the ISO 31000 risk management standard, monitoring and review is defined as the process of continuously checking, supervising, and observing the risk management plan in order to determine if the plan remains suitable to achieve its objectives, and the broader MSP development and environmental objectives, over an unremitting timescale (Cormier et al., 2015). The SMPTE demonstrated an 86.7% conformance ranking in relation to the ICES QMC specific to monitoring and review, scoring 26/30. This represents the second highest conformity ranking amongst all seven sections of the ICES QMC.

4. Discussion

The conformity scores to the ICES QMC indicate that the SMPTE has established a very strong internal context, complete with the appropriate MSP and ecosystem authorities, legislation, policies, strategic aims, goals, and objectives, while clearly engaging both internal and external stakeholders. However, it must be acknowledged that the ICES document is not free from criticism itself, and the 79.5% conformity ranking is only in relation to this document rather than a general QMR of the SMPTE against numerous best practice MSP policy guideline

documents (e.g. UNESCO's *Marine spatial planning: A step by step approach toward ecosystem based management* (Ehler and Douvère, 2009), the European Commission's *MSP Directive 2014/89/EU* (EU, 2014), etc.). This consideration is especially pertinent as the SMPTE is not a contemporary MSP in and of itself, rather, it is a sectoral plan identifying the preferred locations for tidal energy development within Scottish waters with the broader intent of informing Scotland's NMP, which applies management measures to tidal energy development in Scotland (Marine Scotland, 2014). The ICES MSP QMS is a process oriented document which may potentially demonstrate limitations in assessing mature implemented MSPs which are undergoing a statutory review at the 10-year mark. However, this makes it a suitable assessment document in relation to the SMPTE as it is a relatively immature draft plan which requires further process improvements. Given that the SMPTE is a sectoral plan as opposed to an overarching multi-sectoral MSP, a number of audit questions emanating from the QMC were answered utilizing the NMP and various supporting documents in order to account for the larger context of the Scottish marine environment and public policy agenda. However, this has not necessarily resulted in limitations to the assessment as the SMPTE must be in conformity with the objectives and policies set out in the NMP.

The external context is ranked as comparatively weak, although an in depth analysis shows that this is only in relation to the strict conformity to the ICES QMC, as industry and stakeholders have indeed been identified. Rather, the decreased ranking is a result of the absence of publication and solidification of industry and community stakeholder goals and objectives within a concrete timeframe. The SMPTE accounts for this by recognizing that planning is intrinsically a flexible and ongoing communication process between internals and externals, and is framed as such throughout the SMPTE process. However, the QMS suggests that industry and community stakeholder goals and objectives should be established and published at the beginning of the engagement process under a set timeframe in order to refer to a definitive baseline from which set timeframes can demonstrate the evolution of stakeholder input, thereby providing for a more transparent, accountable, and defensible engagement process.

While ranking strong overall, the establishment of the internal context demonstrates shortfalls in relation to employing a formalized consultation, feedback, communication, and decision making process within Marine Scotland (MS) itself. Most consultation, feedback, communication, and decision making was undertaken on an *ad hoc* basis, and lack of a formalized structure may itself cause confusion, lack of accountability and reliability, and subsequently affect the external engagement procedures with industry and community stakeholders (Cormier et al., 2015). It is recommended that a formalized consultation, feedback, communication, and decision making regime internal to MS be established with regards to the SMPTE process.

The establishment of both the external and internal contexts demonstrated an absence of ecosystem management criteria, with the external context lacking ecosystem targets and indicators, as well as the lack of identification of ecosystem boundaries, and the internal context lacking ecosystem management outcomes, significant ecosystem feature justification, as well as the lack of identification of ecosystem boundaries. In theory, this can weaken the ecosystem protection agenda from the very beginning of the SMPTE process, as well as further discussions between internal and external stakeholders pertaining to the status of ecosystem elements, a factor which is jeopardized further when considering the low ranking attributed to the internal consultation, feedback, communication, and decision making processes. It is recommended that the SMPTE strengthen its ecosystem protection agenda so that internal and external stakeholders can work together to define significant ecosystem components, and therefore, potential ecological interactions between marine species and functions with commercial-scale TCT deployment will be better understood by the public, which can reduce the potential for public backlash and subsequent delays in the SMPTE and TCT implementation process

(Alexander et al., 2012).

The SMPTE contained a weak risk identification framework, specifically with regards to identifying and quantifying ecosystem boundaries and services, as well as defining drivers, establishing the criteria used to validate their significance, and their activities both within and outside the management area. These factors ultimately feed into the risk profile, and therefore, any risks not identified due to the absence of ecosystem context quantification and driver activity identification will subsequently be excluded from the risk profile, which in turn eliminates their analysis from the remainder of the SMPTE process and negates the strength demonstrated by the SMPTE evaluation and review and monitoring components (Cormier et al., 2015).

It is recommended that the SMPTE quantify ecosystem services and identify ecosystem boundaries while establishing criteria to determine the significance allotted to drivers and determine the spatial, temporal, and magnitude of driver activities within and outside the management area that may compromise such ecosystem services within ecosystem boundaries. Although the SMPTE is strategic in nature and its construction is predicated on the notion of informing the strategic siting of tidal energy development within the broader context of the NMP, impacts resulting from commercial-scale TCT array implementation can potentially alter natural hydrographic patterns (Bryden et al., 2007) and cause sediment deposition in the far field (Ahmadian et al., 2012), thereby affecting the larger marine ecosystem up and downstream. However, these issues will have to be informed by the NMP, as its geographic reach can facilitate the management of ecosystem-scale boundaries.

Similarly, the risk analysis framework is relatively weak. This is a result from gaps concerning the quantification of the pressure-activity-state change-impact chain, duration and trajectory of recovery, feasibility of mitigation or restoration strategies, and methods used to conduct cause and effect analysis cannot yet be established due to the early stages of SMPTE implementation, the pre-commercial stage in which TCT implementation currently resides, and the SMPTE's status as the first sectoral tidal energy plan devised in the world. Although, as the SMPTE and the tidal energy industry develop in the near future, it is recommended that components of the cause and effect analysis should be quantified in order to better inform ecosystem services, impacts and consequences, economic consequences, driver conflicts, and legal repercussions, and subsequently the risk profile and significant driver activities and pressures in which cause and effect analysis components directly feed in to.

In contrast, the SMPTE demonstrates a very strong risk evaluation framework. The only weakness discovered in the QMR was that no individual or group of individuals have been delegated responsibility to review the risk register. Although the risk register itself is not yet in place due to the early stages of SMPTE implementation, the pre-commercial stage in which TCT implementation currently resides, and the SMPTE's status as the first sectoral tidal energy plan devised in the world, the lack of delegation of authority to individual MS employees over consultation, feedback, communication, and decision making process has become a persistent theme first identified in the establishment of the internal context. It is therefore recommended that an individual or group of individual MS employees be delegated responsibility to review the risk register in order to provide for a more structured and accountable SMPTE process.

The SMPTE demonstrates a weak risk treatment framework, meaning that even when risks are identified in the weak risk identification process, analyzed, and evaluated in the strong risk evaluation process, their treatment may be insufficient and, therefore, the strong monitoring and review component will have to inform the reiteration of the several facets of the SMPTE process in a timelier and costlier manner than would be necessary if risks were appropriately identified from the start. This dilemma has the potential to evoke a distrust in regulators and spur public backlash (Bronfman et al., 2012), thereby hindering the commercial deployment of TCT arrays and subsequently

limit the potential for the SMPTE to meet the SG strategic development objectives for tidal energy implementation in Scotland (Marine Scotland, 2013).

Specifically, the SMPTE risk treatment process lacks clarity on how management options will be undertaken, as the economic and technical feasibility of management options, costs of implementation, and thresholds of public acceptance are not quantified, while plans and programmes that will require updating following management implementation have yet to be considered. Furthermore, criteria used to inform consultation processes justifying how management measures may prompt a reduction in risk pertaining to traditional, cultural, social, and economic ecosystem services have not been identified. Such management option criteria form an upper tier foundation which is clearly linked to the output of the SMPTE as a final product. Therefore, it is recommended that the SMPTE establish criteria to identify economic, technical, financial, social, traditional, and cultural management options pertaining to the treatment of risk, and the associated consultation measures to inform such criteria, in order to effectively alleviate and/or mitigate the potential for risk in relation to tidal energy development within and outside the SMPTE management area.

The SMPTE demonstrates a strong monitoring and review framework. Gaps identified in the monitoring and review component consist of the lack of identification of criteria to determine the effectiveness of management measures, particularly pertaining to cultural and socio-economic indicators and human and financial resource quantification. However, this is mostly due to the early stages of SMPTE implementation, the pre-commercial stage in which TCT implementation currently resides, and the SMPTE's status as the first sectoral tidal energy plan devised in the world, and therefore, such monitoring data are not yet available. It is recommended that criteria be established to identify cultural, socio-economic monitoring measures, and the associated human and financial resources required to implement such measures as the SMPTE and tidal energy industry develop in the near future, thereby providing a baseline of cultural and socio-economic thresholds and associated expenditures. All recommendations emanating from the QMR are summarized in Table 2.

5. Conclusion

Key drivers pertaining to meeting established national GHG emissions reductions and renewable energy implementation targets, in conjunction with the acknowledgement of increasing marine user – user and user – environment conflicts, prompted the SG to produce the world's first SMPTE (Marine Scotland, 2013). Due to the early stages of SMPTE implementation, the pre-commercial stage in which TCT implementation broadly currently resides, and the SMPTE's status as the first sectoral tidal energy plan devised in the world, it is imperative that the SMPTE process be constructed in such a manner to streamline the licensing and permitting processes that facilitate the eventual commercial deployment of TCTs, as can be seen in the implementation of the first commercial TCT array at the MeyGen project (MeyGen, 2016). In light of this, this paper undertook a QMR of Scotland's SMPTE against criteria set out in the recently published MSP best practice guideline document, the ICES MSP QMS.

Overall, the QMR demonstrated a 79.5% compliance ranking of the SMPTE in relation to the ICES criteria, with risk evaluation, monitoring and review, and establishment of the internal context framework demonstrating strong conformity, risk analysis demonstrating sub-par conformity, and risk identification, risk treatment, and the establishment of the external context demonstrating comparatively low conformity. A more in depth analysis suggests that the SMPTE process should establish a formalized consultation, feedback, communication, and decision making regime internal to MS, quantify ecosystem services, define ecosystem boundaries, establish criteria to justify the allotment of significant drivers within and outside the management area, define risk treatment management plans, and provide baseline

Table 2
QMR recommendations for the SMPTE.

Quality Management Review Recommendations	
1.	Industry and community stakeholder goals and objectives should be established and published at the beginning of the engagement process under a set timeframe.
2.	A formalized consultation, feedback, communication, and decision making regime internal to MS should be established for the SMPTE process.
3.	The SMPTE should strengthen its ecosystem protection agenda so that internal and external stakeholders can work together to define significant ecosystem components, and therefore potential ecological interactions between marine species and functions with commercial-scale TCT deployment will be better understood by the public.
4.	The SMPTE should quantify ecosystem services and identify ecosystem boundaries while establishing criteria to determine the significance allotted to drivers and determine the spatial, temporal, and magnitude of driver activities within and outside the management area that may compromise such ecosystem services within ecosystem boundaries.
5.	Components of the cause and effect analysis should be quantified in order to better inform ecosystem services, impacts, and consequences, economic consequences, driver conflicts, and legal repercussions, and subsequently the risk profile and significant driver activities and pressures in which cause and effect analysis components directly feed in to.
6.	An individual or group of individual MS employees should be delegated responsibility to review the risk register in order to provide for a more structured and accountable SMPTE process.
7.	The SMPTE should establish criteria to identify economic, technical, financial, social, traditional, and cultural management options pertaining to the treatment of risk, and the associated consultation measures to inform such criteria, in order to effectively alleviate and/or mitigate the potential for risk in relation to tidal energy development within and outside the SMPTE management area.
8.	It is recommended that criteria be established to identify cultural and socio-economic monitoring measures, and the associated human and financial resources required to implement such measures.

estimates for human and financial resource requirements.

With respect to the ICES MSP QMS as a best practice guideline, the document was chosen as it places emphasis on the process of constructing a MSP, it was the most recent MSP guideline at the time this manuscript was written, and proclaims to be structured to guide any MSP, whether economically, environmentally, or socially oriented (Cormier et al., 2015). However, while the ICES document places emphasis on the importance of integrated coastal zone management (ICZM) as a strategic protocol which should be intimately intertwined with MSP, none of the 178 QMC questions consider the position which ICZM plays in marine management. It is therefore recommended that potential future iterations or follow-up QMSs consider the integration of MSP with ICZM, and possibly extend this to specific aspects of terrestrial planning.

The construction of Scotland's SMPTE can act as a best practice framework in itself for other nations with tidal current energy potential to base their MSPs around, whether they are taken in a sectoral context or as a part of a broader national MSP. Such planning efforts are essential in order to create a governance structure that facilitates the transition of TCTs from the pre-commercial to the commercial implementation stage, thereby making them a viable global player to assist the transition of the world economy from carbon-based to renewables. This QMR can further inform nations constructing a MSP in relation to tidal energy development of what factors have been, should be, and must be considered in the development of their plan. The criteria set out in this framework should not only be limited to sectoral or national tidal energy planning, but can be adopted to inform broader regional, ecosystem-based, and international MSP collaborations such as NorthSEE (EU, 2017a), SimCelt (EU, 2017b), and MUSES (EU, 2017c), in order to set in motion a governance structure and associated regulatory framework that accounts for environmental, ecological, economic, social, traditional, and cultural elements pertaining to user – user, user – environment, and climate change factors related to marine environmental management.

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References

- Ahmadian, R., Falconer, R., Bockelmann-Evans, B., 2012. Far-field modelling of the hydro-environmental impact of tidal stream turbines. *Renew. Energy* 38 (1), 107–116.

- Alexander, K.A., Janssen, R., Arciniegas, G., O'Higgins, T.G., Eikelboom, T., Wilding, T.A., 2012. Interactive marine spatial planning: siting tidal energy arrays around the Mull of Kintyre. *PLoS One* 7 (1), e30031.
- Bronfman, N.C., Jiménez, R.B., Arévalo, P.C., Cifuentes, L.A., 2012. Understanding social acceptance of electricity generation sources. *Energy Pol.* 46, 246–252.
- Bryden, I.G., Couch, S.J., Owen, A., Melville, G., 2007. Tidal current resource assessment. *Proc. IME J. Power Energy* 221 (2), 125–135.
- Cormier, R., Kannen, A., Elliott, M., Hall, P., Davies, I.M., 2013. Marine and Coastal Ecosystem-based Risk Management Handbook. ICES Cooperative Research Report, pp. 60 No. 317.
- Cormier, R., Kannen, A., Elliott, M., Hall, P., 2015. Marine Spatial Planning Quality Management System. ICES Cooperative Research Report No. 327. 106 pp.
- Davies, I.M., Pratt, D., 2014. Strategic sectoral planning for offshore renewable energy in Scotland. In: *Marine Renewable Energy Technology and Environmental Interactions* (pp. 141–152). Springer, Netherlands.
- Douvere, F., 2008. The importance of marine spatial planning in advancing ecosystem-based sea use management. *Mar. Pol.* 32 (5), 762–771.
- Douvere, F., Ehler, C.N., 2009. New perspectives on sea use management: initial findings from European experience with marine spatial planning. *J. Environ. Manag.* 90 (1), 77–88.
- European Commission (EC), 2013. Directive of the European Parliament and of the Council: Establishing a Framework for Maritime Spatial Planning and Integrated Coastal Management. Brussels, COM (2013) 133 final.
- Ehler, C., Douvere, F., Intergovernmental Oceanographic Commission, 2009. Marine spatial planning: a Step-by-step Approach toward Ecosystem-based management. UNESCO.
- Elliott, M., 2013. The 10-tenets for integrated, successful and sustainable marine management. *Mar. Pollut. Bull.* 74 (1), 1.
- European Union – EU, 2014. Maritime spatial planning directive 2014/89/EU. Retrieved from: <https://www.eea.europa.eu/policy-documents/directive-2014-89-eu-maritime>.
- European Union – EU, 2017a. A North sea perspective on shipping, energy and environmental aspects in Maritime spatial planning – NorthSEE. Retrieved from: <http://www.northsearegion.eu/northsee/>.
- European Union – EU, 2017b. SimCelt. Retrieved from: <http://www.simcelt.eu/>.
- European Union – EU, 2017c. Multi-Use in European seas – MUSES. Retrieved from: <https://muses-project.eu/>.
- European Union (EU), 2012. Blue Growth Opportunities for Marine and Maritime Sustainable Growth. Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions. COM (2012) 494 final.
- Foley, M.M., Halpern, B.S., Micheli, F., Armsby, M.H., Caldwell, M.R., Crain, C.M., Prahler, E., Rohr, N., Sivas, D., Beck, M.W., Carr, M.H., Crowder, L.B., Duffy, E.J., Hacker, S.D., McLeod, K.L., Palumbi, S.R., Peterson, C.H., Regan, H.M., Ruckelshaus, M.H., Sandifer, P.A., Steneck, R.S., 2010. Guiding ecological principles for marine spatial planning. *Mar. Pol.* 34 (5), 955–966.
- Fraenkel, P.L., 2002. Power from marine currents. *Proceedings of the institution of mechanical engineers, Part A. J. Power Energy* 216 (1), 1–14.
- Fraenkel, P.L., 2006. Tidal current energy technologies. *Ibis* 148 (s1), 145–151.
- Halpern, B.S., Walbridge, S., Selkoe, K.A., Kappel, C.V., Micheli, F., D'Agrosa, C., Bruno, J., Casey, K.S., Ebert, C., Fox, H.E., Fujita, R., Heinemann, D., Lenihan, H.S., Madin, E.M.P., Perry, M., Selig, E.R., Spalding, M., Steneck, R., Watson, R., 2008. A global map of human impact on marine ecosystems. *Science* 319 (5865), 948–952.
- Hoyle, D., 2011. Process management principles. In: *ISO 9000 Quality Systems Handbook: Using the Standards as a Framework for Business Improvement*. pp. 157–158, sixth ed. Routledge, New York, 978-1-8561-7684-2, pp. 802.
- ICES, 2012. Joint DFO/KnowSeas, and ICES Workshop on Quality Management in MSP (WQAMSP), 28 February– 1 March 2012, Dartmouth, Canada. ICES, pp. 48 CM 2012/SSGHE:02.
- ISO, 2005. Quality Management Systems-Fundamentals and Vocabulary. International

- Organization for Standardization ISO 9000:2005(E).
- ISO, 2009. Risk Management Principles and Guidelines. International Organization for Standardization ISO 31000:2009(E).
- Lester, S.E., Costello, C., Halpern, B.S., Gaines, S.D., White, C., Barth, J.A., 2013. Evaluating tradeoffs among ecosystem services to inform marine spatial planning. *Mar. Pol.* 38, 80–89.
- Marine Scotland (UK), 2013. Planning Scotland's seas: sectoral marine plans for offshore wind, wave, and tidal energy in Scottish waters consultation draft. <http://www.gov.scot/Publications/2013/07/8702>.
- Marine Scotland (UK), 2014. Scotland's National Marine Plan. Marine Scotland. Edinburgh, UK.
- MeyGen. (2016). Retrieved from www.meygen.com.
- Myers, L.E., Keogh, B., Bahaj, A.S., 2011, September. Layout optimisation of 1st generation tidal energy arrays. In: Proc. of 9th European Wave and Tidal Energy Conference.
- Pelc, R., Fujita, R.M., 2002. Renewable energy from the ocean. *Mar. Pol.* 26 (6), 471–479.
- Rice, J., Trujillo, V., Jennings, S., Hylland, K., Hagstrom, O., Astudillo, A., Nørrevang-Jensen, J., 2005. Guidance on the Application of the Ecosystem Approach to Management of Human Activities in the European Marine Environment. ICES Cooperative Research Report, pp. 22 No. 273.
- Sardà, R., Diedrich, A., Tintoré, J., Pablo Lozoya, J., Cormier, R., Hardy, M., Ouellette, M., 2010. Decision making (DEMA) tool and demonstration. KnowSeas. Deliverable 6.2 development of risk assessment. In: European Community's Seventh Framework Programme [FP7/2007-2013] under Grant Agreement Number 226675.
- Sardà, R., O'Higgins, T., Cormier, R., Diedrich, A., Tintoré, J., 2014. A proposed ecosystem-based management system for marine waters: linking the theory of environmental policy to the practice of environmental management. *Ecol. Soc.* 19 (4), 51.
- Schultz-Zehden, A., Gee, K., Scibior, K., 2008. Handbook on Integrated Maritime Spatial Planning. INTERREG III B CADSES PlanCoast Project.
- The Scottish Government, 2009. Climate change (Scotland) act 2009. Retrieved from: <http://www.gov.scot/Topics/Environment/climatechange/scotlands-action/climatechangeact>.
- The Scottish Government, 2010. Marine (Scotland) act 2010. Retrieved from: <http://www.legislation.gov.uk/asp/2010/5/contents>.
- The UK Government, 2009. Marine and coastal access act 2009. Retrieved from: <https://www.legislation.gov.uk/ukpga/2009/23/contents>.
- UN Atlas of the Oceans, 2010. Human settlements on the coast. Retrieved from: <http://www.oceansatlas.org/servlet/CDSServlet>.
- World Resources Institute, 2005. Millennium ecosystem assessment. Summary for Decision-Makers. 2005.